

REMARKS/ARGUMENTS

Claims 1 to 18 are currently pending in this application. Claim 1 has been amended. No new matter has been introduced by the amendments set forth in this response.

Rejections Under 35 U.S.C. §103

We are pleased that the Examiner found merit on our previous responses with regard to the Patten, Apfel and Johnson et al. references. The sole remaining rejection concerns the Kang et al. reference. Specifically, the Examiner rejected claims 1 to 18 under 35 U.S.C. §103(a), as being unpatentable over Kang et al. (U.S.P.N. 7,073,560). Applicants respectfully traverse this rejection.

As has been discussed in previous Office action responses, the current claims are directed to a method of forming an amorphous foam in accordance with the following steps:

- Heating the alloy to its liquidus temperature and introducing bubbles into the alloy where the bubbles have a specific internal bubble pressure;
- Cooling the precursor *to a temperature between the nose of the crystallization curve and above the glass transition temperature of the alloy* by providing a pressure gradient to the precursor where the pressure during the expansion is lower than the internal bubble pressure of the introduced gas bubbles formed during the precursor forming step.
[Italics added for emphasis]

As has also been previously argued, the processes described in the Kang et al. patent differ in a number of significant ways from the process of the current application. The most striking of these differences is the contrast between the foam formation temperature profile proposed by the current application and that proposed by the Kang et al. patent. Specifically, the current application teaches that the molten alloy with the

bubble precursors should be cooled below the nose of the crystallization curve and above the glass transition temperature and then the bubbles allowed to be formed. For example, the specification of the current application sets forth the specifics of this temperature regime in particular detail. (Specification, page 9, lines 5 to 25.) Moreover, the important of this temperature window is highlighted in the specification where Applicants state:

The applicants discovered that the sluggish crystallization kinetics [in the thermoplastic zone] [see FIG. 1] can be beneficially exploited to develop novel processing methods for bulk-solidifying amorphous alloy foam structures. Furthermore, the applicants discovered that utilizing these novel processing methods and by accessing a large regime of viscosity values, between ~ 1 Pas and $\sim 10^{13}$ Pas, highly homogeneous and controllable amorphous metallic foam structures can be obtained. Applicants further discovered that these novel methods of processing amorphous alloys into metallic foam structures can substantially forego or relax the dimensional limitations arising from the critical cooling rate to form an amorphous phase. (Specification, paragraphs 46 & 47.)

In contrast, Kang et al. specifically and repeatedly state that the formation of bubbles should occur at a temperature of where the alloy is in a molten state. For example, Kang et al. write:

The invention is also directed to methods of forming the foamed structures described above. In one particular embodiment of the method, the steps of which are outlined in FIG. 2, a feedstock bulk-solidifying amorphous alloy is heated to a temperature above the

melting temperature to form a molten bulk solidifying amorphous alloy (defined as the melting temperature of the corresponding crystalline phase for the given composition). In such an embodiment, the feedstock of the alloy is not necessarily in an amorphous atomic structure. This molten bulk solidifying amorphous alloy is then pressurized. In such a step the pressure can be from 15 psi to up to 15,000 psi. The pressurized molten alloy is then rapidly stirred to form and trap bubbles. The stirring tool is a refractory tool such as made of graphite, carbide (WC, BC), nitrides, other refractory such as Zirconia or refractory metals such as tungsten and molybdenum. The stirring tool is typically in the shape of propeller and spun at rates of from 30 rpm to 1200 rpm. The spinning rate can be up to 5,000 rpm or more in order to achieve a higher volume fraction of pore, more than about 30%. The rate of spinning can be adjusted to get the desired size pore (bubble) size and distribution. Finally, the mixture of bubble and molten alloy is cooled below the glass transition temperature of the amorphous alloy to freeze the bubbles into a solidified foam structure. As discussed above, a cooling rate faster than the critical cooling rate of the amorphous alloy is desired in order to ensure the formation of amorphous atomic structure substantially throughout the structure. In such an embodiment, the cooling may be achieved by external means such utilizing a massive cold substrate or convection gas cooling. (Specification, co. 5, lines 10 to 40.)

In short, Kang et al. teach that the bubbles should be formed in a molten state and then frozen into place. The only reference Kang et al. ever make to the use of a thermoplastic temperature is made with regard to shaping a fully formed piece of amorphous foam feedstock. [Kang et al. col. 6, lines 4 to 15.] However, the Examiner appears to take this disclosure regarding the shaping step and conflate it with the process of forming bubbles in the amorphous material. Applicants simply cannot agree with this analysis.

Specifically, while shaping amorphous alloys in a thermoplastic range is relatively well known, see, e.g., U.S.P.N. 7,017,645, previously cited by the Examiner, Applicants have made it clear that what has been more difficult is in understanding how to produce engineered amorphous foams. For example, Applicants write:

However, the broad-use of metallic foams is hindered by the difficulty in producing uniform and consistent foam structures. Specifically, prior manufacturing methods for producing metallic foams result in an undesirably wide distribution of cell and/or pore sizes, which cannot be controlled satisfactorily, and as such limits and degrades the functional and structural characteristics of the metallic foam materials.

The conventional production of metallic foamed structures is generally carried out in the liquid state above the melting temperature of the material, though some solid-state methods have also been used. The foaming of ordinary metals is challenging because a foam is an inherently unstable structure. The reason for the imperfect properties of conventional metallic foams comes from the manufacturing process itself. For example, although a pure metal or metal alloy typically consists of a large volume

fraction (>50%) of gas bubbles, manufacturing metallic foam from ordinary alloys is very difficult because a desired bubble distribution cannot be readily sustained for practical times in their molten state.

Specifically, the time scales for the flotation of bubbles in a foam scales with the viscosity of the material. Accordingly, the mechanical properties of these foams drastically degrade with the degree of imperfection caused by the flotation and bursting of bubbles during manufacture. In addition, the low viscosity of most commonly used liquid metals results in a short time scale for manufacture, which makes the processing of metallic foam a delicate process. (Specification, page 1, line 18 to page 2, line 3.)

In short, while the Kang et al. patent does provide a number of improvements to the process of alloy formation, it does not address the specific issues being advanced by the current application. Moreover, the process taught by Kang et al. actually perpetuates the conventional understanding of how amorphous foams should be formed, namely in the molten state. For the Examiner to dismiss the importance of Applicants' surprising discovery that bubble formation in amorphous materials can be enhanced by working within the narrow temperature window specified in the claims of the current application by stating, without support, that it "would have been obvious . . . in view of the entire specification as a whole" is simply inappropriate.

The entire thrust of the current application is that one should turn away from the conventional method of forming foams by forming those bubbles within a specific formation window defined by the crystallization nose and the glass transition temperature of the alloy. The Examiner has put forth no single or combination of references that teach that bubble formation in amorphous foams should be conducted

at the viscosity and temperature range proposed. Indeed, the single reference remaining at issue in the prosecution of the current application specifically teaches away from such a methodology, itself teaching that the bubble should be processed in a molten state.

Accordingly, Applicants submit that one of skill in the art would rightly concluded that the Kang et al. teaching is not at all applicable to the foam processing method of the current invention. As such, Applicants would respectfully submit that the current invention simply cannot be considered obvious in view of the disclosure of the Kang et al. patent.

Conclusion

In view of the foregoing amendment and response, it is believed that the application is in condition for further examination. If any questions remain regarding the allowability of the application, Applicant would appreciate if the Examiner would advise the undersigned by telephone.

Respectfully submitted,

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